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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the projected type display using the polarization separation element used in case the space optical modulator which mainly uses polarization of light is illuminated, and the polarization separation element concerned.

[0002]

[Description of the Prior Art] Conventionally, thing ** using the thing using CRT as projected type display which carries out expansion projection of the subject-copy image using a projection lens, the light source, and a space optical modulator is known. The penetrated type liquid crystal panel using the twist nematic liquid crystal as a space optical modulator is known, and if a panel with abundant that the miniaturization of a projection machine is easy and numbers of pixels is used, it is widely put in practical use from that a high definition picture can be projected, the mass production technology of a liquid crystal panel being established for the accepting-reality use, etc.

[0003] Since a twist nematic liquid crystal uses polarization of light, such a space optical modulator equips an incidence and outgoing radiation side with a polarizer. The polarization state of the light of the linearly polarized light which passed the polarizer by the side of incidence among the light which illuminates a space optical modulator is made to change spatially, the quantity of light which passes the polarizer by the side of outgoing radiation is controlled, and an optical image is formed.

[0004] Generally the projected type display using the space optical modulator illuminates a space optical modulator using the lamp which emits the natural light. When a space optical modulator is a thing using polarization of light, only the light of the abbreviation half of the natural light which a lamp emits does not pass the polarizer by the side of incidence, and light other than this is reflected or absorbed, and is lost.

[0005] On the other hand, the various proposals of the technology called polarization conversion are made. This divides the natural light of the light source into the light of a required polarization component, and the light of the polarization component which intersects perpendicularly with this beforehand, tends to rotate the plane of polarization of the light of the polarization component which cannot be used if it remains as it is 90 degrees, after it arranges the plane of polarization of two light, it tends to be supplied to a space optical modulator, and it tends to use these.

[0006] Therefore, the polarization separation element which divides the natural light into the light of two polarization components and the polarization direction cross at right angles mutually, and the plane-of-polarization rotation element which rotates the plane of polarization of the polarization light of one of the two which dissociated 90 degrees are required for the projected type display using polarization conversion. As a polarization separation element, the polarization separation multilayer using a brewster's angle and interference is known widely, and there is a monotonous type and prism type polarization separation element.

[0007] On the other hand, generally as a plane-of-polarization rotation element, the phase film called lambda/2 board is known. This is what 1 shaft orientations were made to extend a transparent organic film optically, and gave the optical anisotropy, and gives the phase contrast equivalent to one half of wavelength lambda to the light which controls and penetrates the thickness and optical anisotropy.

[0008] When incidence of the light of the linearly polarized light which has plane of polarization in the direction of 45 degrees to an optical axis is carried out to lambda/2 board, outgoing radiation light turns into the linearly polarized light which plane of polarization rotated 90 degrees.

[0009]

[Problem(s) to be Solved by the Invention] As for the optical system used for the composition of polarization conversion or this which is proposed from the former, neither acquires sufficient effect from the original purpose.

[0010] It is called primary polarization about the light of the polarization direction which a space optical modulator originally uses hereafter in the optical path which results in a space optical modulator from the light source, and before rotating plane of polarization, it is called secondary polarization about the light of the polarization direction which intersects perpendicularly with this. Moreover, it considers as a primary optical axis about the optical path which primary polarization passes, and considers as a secondary optical axis about the optical path which secondary polarization passes.

[0011] When realizing polarization conversion, the efficiency for light utilization of the whole optical system must fully be high about both primary polarization and secondary polarization. If the efficiency of primary polarization falls greatly by using polarization conversion as compared with the case where it does not use, the increase in the efficiency for light utilization by

having introduced polarization conversion loses in weight, and the original purpose of raising a luminosity cannot fully be attained.

[0012] Moreover, secondary polarization must not make the luminosity unevenness or irregular color of light which illuminate a space optical modulator increase. Since the lighting unevenness of lighting light turns into brightness unevenness of a projection picture, and an irregular color, a problem has it.

[0013] furthermore, what a means to realize polarization conversion cheats out of the optical path length of primary polarization and secondary polarization remarkably long, the thing to which the size of optical system is made to increase greatly, and the thing which makes cost of optical system remarkably expensive -- don't come out The problem to which the projected type display which the optical loss in a long optical path increases becomes large of becoming expensive is produced.

[0014] What is indicated by JP,3-13983,A, JP,4-63318,A, JP,4-177335,A, JP,5-27203,A, and JP,7-64075,A as conventional polarization conversion technology from the reason for the above is not enough. Since the prism with which all deposited the polarization separation multilayer is used, it has the problem to which the optical path length of the large-scale primary polarization with an expensive polarization separation element and secondary polarization is made to increase that where of the effect that the optical path length from the light source to a space optical modulator makes bright a projection picture which is greatly different by primary polarization and secondary polarization is not enough.

[0015] Especially the thing for which the optical path length from the light source to a space optical modulator is made the same by primary polarization and secondary polarization is important. About both primary polarization and secondary polarization, the light which carries out outgoing radiation from the light source is condensed, it transmits and the conditions to illuminate can be made the same. Since making efficiency for light utilization high and making [of the same grade]-homogeneity of lighting light ** become easy about the light of both polarization directions, this is desirable. It is bright and the few projection picture of display unevenness can be offered.

[0016] On the other hand, the polarization separation element indicated by JP,3-174502,A puts the optically uniaxial birefringence material which arranged the optical axis with the interface of two prism, carries out total reflection only of either of the two polarization directions alternatively, and separates polarization. Although it is excellent in thermal resistance and polarization separation efficiency, a polarization separation element is large, and since this uses the glass prism on bulk, it is expensive. Moreover, since the optical path length which acts becomes long, there is a problem.

[0017] Moreover, the optical system indicated by JP,4-234016,A makes the same the optical path length from the light source to a space optical modulator about primary polarization and secondary polarization. Although this is desirable when treating the light of both polarization on the same conditions, the composition indicated by the official report concerned has the problem that the whole optical path length is long and the size of the whole set becomes large. Moreover, there are also many part mark.

[0018] Furthermore, the optical system indicated by JP,6-202094,A is indicating an example of optical system which can use both primary polarization and secondary polarization using a thin polarization separation element. The composition of this optical system is shown in (drawing 13).

[0019] It is condensed by the parabolic mirror 902 and the natural light emitted from a lamp 901 illuminates a liquid crystal panel 907 through the 1st lens array 904 and the 2nd lens array 905. The 1st lens array 904 divides the lighting flux of light, and the flux of light after division is expanded to a suitable size by the 2nd lens array 905. A convex lens 908 makes each divided flux of light superimpose on a panel. The convex lens 909 near the panel uses the chief ray in each field angle of lighting light as an optical axis at parallel.

[0020] 903 is a polarization separation element and shows an example of the composition to (drawing 14). This carries out outgoing radiation of the light of primary polarization, and the light of secondary polarization as a light from which travelling direction differs only in angle theta. Thereby, only in predetermined distance, the spot of the flux of light which the 1st lens array 904 makes converge on opening of the 2nd lens array 905 shifts in the direction of angle theta in primary polarization and secondary polarization. [near the opening of the 2nd lens array 905], the phase contrast board 906 is made to act only on the spot on which secondary polarization was converged alternatively, this plane of polarization is rotated 90 degrees, and the plane of polarization of the light of the primary polarization which carries out outgoing radiation from the 2nd lens array 905, and secondary polarization is arranged in the same direction. If this is made to correspond in the polarization direction of the incidence side polarizing plate of a liquid crystal panel 907, the high optical system of efficiency for light utilization is realizable.

[0021] It supplements with an example of the composition of the polarization separation element 903. A flat-surface substrate and 913 are supposed that a prism array substrate serrate in 911 and 912 are birefringence optical-material layers, and can use a liquid crystal layer, an organic film, a monomer, etc. Combining the prism layer which a refractive index makes isotropic prism adjoin and becomes from birefringence material, making the conditions of the refraction in a prism interface differ about the polarization direction which intersects perpendicularly, making two polarization light separate and changing travelling direction is widely known as a Wollaston prism. The polarization separation element 903 makes this the shape of an array, generally, tends to carry out orientation of the organic materials, such as liquid crystal and a monomer, to 1 shaft orientations, and tends to use the point using a calcite expensive as a birefringence material.

[0022] The above-mentioned operation has the following technical problems in fact, although the polarization separation element 903 is obtained theoretically. Liquid crystal and an organic film have a problem, when arranging and using it near the light source which emits high temperature, since it is comparatively weak with heat.

[0023] Moreover, a serrate prism array will be considered that this periodic pitch is required for at least 1mm or more if it takes processing a good configuration into consideration. In this case, the thickness of a birefringence material layer is also needed

about at least 1mm. Although carrying out orientation of the molecule which has form birefringence, such as liquid crystal, to 1 shaft orientations by methods, such as a magnetic field, electric field, and rubbing, is known widely, to be able to carry out orientation generally is made into the thickness of dozens of microns even if large, and the method or material to which orientation of the several mm thick whole layer is carried out good uniformly are not known widely. It is not indicated by JP,6-202094,A about this point.

[0024] Therefore, the projected type display using the polarization separation element of the above-mentioned composition and this has a big problem, when embodying the polarization separation element which has a desired operation.

[0025] Furthermore, JP,8-234205,A is made in view of the point describing above, and is indicating the composition which combined the polarization selectivity mirror which becomes the prism of the letter of bulk from a multilayer as a polarization separation element. Small polarization selectivity prism is arranged in the shape of an array, and an example of the method of constituting a thin polarization separation element is also indicated.

[0026] However, it has the problem that efficiency complicated [the composition of a prism array with expensive prism for which any of this method needs the optical path length long in order to arrange prism], and sufficient is not acquired.

[0027] this invention is made in view of the above-mentioned problem, and it aims at embodiment offering the high polarization separation element of efficiency with a comparatively easy thin shape. Furthermore, it aims at offering the projected type display with which efficiency for light utilization offers a bright high display image using the polarization separation element concerned.

[0028]

[Means for Solving the Problem] In order to solve the above-mentioned trouble the 1st polarization separation element of this invention A polarization component which has the oscillating component of electric field for the natural light which carries out incidence in the Direction A, The translucency substrate which is the polarization separation element which separates and carries out outgoing radiation to B polarization component which has the oscillating component of electric field in Direction A and the direction B which intersects perpendicularly, and is arranged by carrying out an abbreviation rectangular cross at the optical axis of an incident light, It consists of a diffraction grating which has periodic structure in the 1 shaft orientations C along the substrate front face, and an optically-anisotropic-body layer which adjoins a diffraction grating and is formed. An optically-anisotropic-body layer has a different refractive index in the direction D which intersects perpendicularly with Direction C and this on a substrate front face. a diffraction grating Shall act alternatively only about any one polarization component of A polarization component or the B polarization component, only a predetermined angle shall make the light of the polarization component concerned diffract, and the light of A polarization component and the light of B polarization component shall carry out outgoing radiation of these as a light from which travelling direction differs mutually.

[0029] In order to solve the above-mentioned trouble moreover, the 1st projected type display of this invention The light source which emits the natural light, and a condensing means to form the light which is made to condense the light which the light source emits and advances to abbreviation 1 shaft orientations, The polarization separation element in which the light which carries out outgoing radiation from a condensing means carries out incidence, and the 1st lens array arranged near the polarization separation element, The 2nd lens array in which the light which carries out outgoing radiation from the 1st lens array carries out incidence, and a plane-of-polarization rotation means to make it act alternatively about a part of light in which it is arranged near the 2nd lens array and the lens array concerned is passed, It has the space optical modulator by which the light which carries out outgoing radiation from the 2nd lens array is irradiated, and the projection lens which projects the optical image on a space optical modulator. A polarization separation element is the 1st polarization separation element of the above-mentioned publication, and a space optical modulator acts on the light of the linearly polarized light, and forms an optical image. The 1st lens array comes to arrange two or more 1st lenses in the shape of-dimensional [2], and the 2nd lens array comes to arrange the 1st lens and two or more 2nd lenses which make a pair in the shape of-dimensional [2]. It is made to converge the light of A polarization component and the light of B polarization component from which travelling direction differs mutually on the position where openings of the 2nd lens which corresponds with the 1st lens differ. A plane-of-polarization rotation means acts only on the light of any one polarization component on opening of the 2nd lens alternatively, and makes the plane of polarization of the light of the polarization component concerned rotate 90 abbreviation. Abbreviation coincidence of the plane of polarization of the light of A polarization component and the plane of polarization of the light of B polarization component which are irradiated by the space optical modulator is carried out, and these are used.

[0030] In order to solve the above-mentioned trouble moreover, the 2nd polarization separation element of this invention A polarization component which has the oscillating component of electric field for the natural light which carries out incidence in the Direction A, It is the polarization separation element which separates and carries out outgoing radiation to B polarization component which has the oscillating component of electric field in Direction A and the direction B which intersects perpendicularly. The polarization separation element concerned is arranged in the shape of-dimensional [2], and constitutes the polarization separative element of two or more units. one unit of a polarization separative element Outgoing radiation is carried out so that the light of A polarization component and the light of B polarization component may constitute a predetermined separation angle in the predetermined direction and travelling direction may differ mutually, and it is the thing of a polarization separative element it is made to make separation angles differ about either at least.

[0031] It sets for the 2nd polarization separation element of this invention desirably. a polarization separative element The translucency substrate arranged by carrying out an abbreviation rectangular cross at the optical axis of an incident light, and the diffraction grating which has periodic structure in the 1 shaft orientations C along the substrate front face, It consists of an optically-anisotropic-body layer which adjoins a diffraction grating and is formed, and an optically-anisotropic-body layer has a different refractive index in the direction D which intersects perpendicularly with Direction C and this on a substrate front face. a

diffraction grating Act alternatively only about any one polarization component of A polarization component or the B polarization component, only a predetermined angle makes the light of the polarization component concerned diffract, the pitches of a diffraction grating are made to differ, and it is made to make the separation angles of the polarization separative element concerned differ appropriately.

[0032] In order to solve the above-mentioned trouble furthermore, the 2nd projected type display of this invention The light source which emits the natural light, and a condensing means to form the light which is made to condense the light which the light source emits and advances to abbreviation 1 shaft orientations, The polarization separation element in which the light which carries out outgoing radiation from a condensing means carries out incidence, and the 1st lens array arranged near the polarization separation means, The 2nd lens array in which the light which carries out outgoing radiation from the 1st lens array carries out incidence, and a plane-of-polarization rotation means to make it act alternatively about a part of light in which it is arranged near the 2nd lens array and the lens array concerned is passed, It has the space optical modulator by which the light which carries out outgoing radiation from the 2nd lens array is irradiated, and the projection lens which projects the optical image on a space optical modulator. A space optical modulator acts on the light of the linearly polarized light, and forms an optical image, and the 1st lens array comes to arrange two or more 1st lenses in the shape of-dimensional [2]. The 2nd lens array comes to arrange the 1st lens and two or more 2nd lenses which make a pair in the shape of-dimensional [2]. A polarization separation element is the 2nd polarization separation element of the above-mentioned this invention, and a polarization separation element makes polarization part elongation differ according to the position of the 1st corresponding lens. It is made to adjoin and converge the light of A polarization component and the light of B polarization component from which travelling direction differs mutually on the position where openings of the 2nd lens which corresponds with the 1st lens differ. A plane-of-polarization rotation means acts only on the light of any one polarization component on opening of the 2nd lens alternatively, and makes the plane of polarization of the light of the polarization component concerned rotate 90 abbreviation. Abbreviation coincidence of the plane of polarization of the light of A polarization component and the plane of polarization of the light of B polarization component which are irradiated by the space optical modulator is carried out, and this is used.

[0033]

[Embodiments of the Invention] this invention puts a diffraction grating and an optically uniaxial optically-anisotropic-body layer together as a polarization separation element, and is characterized by the bird clapper. In advance of concrete explanation of this invention, the general well-known matter about a diffraction grating is described first.

[0034] (Drawing 1) is an example of the diffraction grating 11 which comes to form serrate microstructure periodically. The periodic pitch of a serration configuration is set to D, and the maximum height (depth) is set to H.

[0035] if maximum height H [m] gives the phase contrast of 2π from [of a substrate] a normal to the light 12 of wavelength λ [m] which carries out incidence here -- an incident light 12 -- mostly, only angle theta bends as the primary [+] diffracted light, and all become outgoing radiation light 12'

[0036] In this case, it is (several 1) about maximum height H [m], and is (several 2) about an angle of diffraction theta. however, the refractive index of the medium by which Ns wraps the refractive index of a diffraction-grating substrate, and Na wraps a diffraction grating -- it comes out

[0037]

[Equation 1]

$$H = \lambda / (N_s - N_a)$$

[0038]

[Equation 2]

$$\sin \theta = \lambda / D$$

[0039] (Drawing 2) is the example of composition of the diffraction grating 15 known as a binary optical element. This approximates the serrate microstructure of (drawing 1) with stair-like step structure. In this case, the rank of the flat part of a stairway is called number of level, and the diffraction grating 15 is illustrating the case of 7 level.

[0040] A binary optical element has the advantage which a detailed configuration can form comparatively easily by the photolithography which used the semiconductor aligner (stepper optical system). Outgoing radiation of 2π , then the great portion of light 16 which carry out incidence is carried out for the phase contrast which height H gives also in this case as primary [+] diffracted-light 16'. About height H and Pitch D, (several 1) and (several 2) are materialized similarly.

[0041] Moreover, about the case where the numbers of level are 2, 4, 8, and 16, for example, 40.5%, 81%, 95%, 99%, and the bird clapper are known, and, as for theoretical diffraction efficiency, 4 or more [then] and practically almost sufficient diffraction efficiency are obtained in the number of level.

[0042] Next, an example of the polarization separation element of this invention is shown in (drawing 3), and the operation is described. The polarization separation element 101 consists of a diffraction-grating substrate 102 and a birefringence layer 103. In order to give explanation easy, a rectangular coordinate system is introduced, the direction which intersects perpendicularly the direction in alignment with space with a x-y flat surface and space is made into the z-axis, and the polarization separation element 101 shall spread in the shape of-dimensional [2] on a y-z flat surface, and shall carry out incidence of the beam of light 104 considered as criteria along a x axis.

[0043] For example, the diffraction grating 102 is the same as that of what was shown in (drawing 1), and comes to form serrate microstructure in y shaft orientations in Pitch D periodically. The physical maximum height of an interdigitated structure is taken as H. A refractive index forms a diffraction grating 102 using the isotropic transparent substrate of N0.

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[0044] On the other hand, the birefringence layer 103 carries out orientation of the positive optically uniaxial optically anisotropic body so that an optical axis may be in agreement with z shaft orientations, and it is constituted. About the birefringence layer 103, the refractive index of z shaft orientations is set to N1, the refractive index of y shaft orientations is set to N2, and it is referred to as $N1 > N2$.

[0045] About the light 104 of the natural polarization which carries out incidence from [of the substrate of a diffraction grating 102] a normal (x axis), electric field set to primary polarization 104A light of the polarization component which vibrates to z shaft orientations. Similarly, electric field set to secondary polarization 104B light of the polarization component which vibrates to y shaft orientations.

[0046] For example, the refractive index N0 of the base material of a diffraction grating 102 and the refractive index N1 of the birefringence layer 103 are chosen so that $N0 \gg N1$ may be filled. If it carries out like this, a diffraction grating 102 will cease to exist for the light of primary polarization 104A, and primary polarization 104A will go straight on and carry out outgoing radiation of the polarization separation element 101 as it is among incident lights 104.

[0047] On the other hand, since it is $N0 > N2$, to the light of secondary polarization 104B, a diffraction grating 102 acts, and secondary polarization 104B is diffracted and carries out outgoing radiation.

[0048] In this case, height H of a diffraction grating 102 is chosen so that (several 3) may be filled.

[0049]

[Equation 3]

$$H = \lambda / (N_2 - N_0)$$

[0050] This is the conditional expression for the greatest phase contrast which a diffraction grating gives about the light of the criteria wavelength λ being set to 2π from (several 1). As for such a serrate diffraction grating, the primary [+] diffracted light becomes 100% theoretically about the light of wavelength λ . However, what is necessary is just to set criteria wavelength λ to 550nm as wavelength representing a visible wavelength-range region. an angle of diffraction θ -- the periodic pitch D of a diffraction grating -- using -- it is (several 2) .

[0051] From the reason for the above, only + θ diffracts and carries out [the most] outgoing radiation of the secondary polarization 104B among the light 104 which carries out incidence. That is, the polarization separation element 101 acts so that travelling direction may separate and carry out outgoing radiation of the incident light 104 to primary polarization 104A and secondary polarization 104B which make angle θ mutually.

[0052] Furthermore, the polarization separation element of this invention may be the polarization separation element 111 shown in (drawing 4). Instead of the diffraction grating 101 of (drawing 3), this uses the binary optical element shown in (drawing 2). The same rectangular coordinate system as (drawing 3) is introduced.

[0053] For example, a diffraction grating 112 is what formed stair-like microstructure in y shaft orientations periodically in Pitch D, and sets the number of level to 7. Concretely, the division-into-equal-parts rate of the round term D is carried out to seven strip-of-paper fields, equal step height $H / 6$ are accumulated one by one, and a stairway configuration is constituted. Sign H is the physical maximum height of a stairway configuration. The base material of a diffraction grating 112 considers as the isotropic transparent material of a refractive index N0, and the birefringence layer 113 presupposes that it is the same as that of what was shown in (drawing 3).

[0054] The light of primary polarization 114A whose oscillating directions of electric field are z shaft orientations does not receive an operation of a diffraction grating 112, but goes straight on and carries out outgoing radiation of the polarization separation element 111 as it is. On the other hand, the light of secondary polarization 114B whose oscillating directions of electric field are y shaft orientations is diffracted by the diffraction grating 112, and carries out outgoing radiation.

[0055] Also in this case, maximum height H of a diffraction grating 112 is chosen so that the phase contrast given to the criteria wavelength λ may be set to 2π . Thus, the primary [+] diffracted light becomes dominant, and if the binary optical element of the shape of a selected step is the about seven number of level, it will serve as practically sufficient diffraction efficiency. the angle of diffraction θ of secondary polarization 114B -- the periodic pitch D of a diffraction grating -- using (several 2) -- it is the same

[0056] Since a diffraction grating is used for the polarization separation element shown in (drawing 3) and (drawing 4), it is characterized by the thickness of the birefringence layers 103 and 113 being very thin. In order to obtain the angle of diffraction of about 10 degrees, Pitch D is about several microns and becomes of the same grade [the height of a diffraction grating]. Therefore, the microstructure section of a diffraction grating is filled up with a liquid crystal molecule, a liquid crystal monomer, a liquid crystal polymer, an optically uniaxial organic material, etc., it is very easy to carry out orientation to 1 predetermined shaft orientations, and the polarization separation element excellent in implementability and mass-production nature can be obtained.

[0057] When it constitutes the diffraction element of a minute pitch especially, the binary optical element is excellent in processability. Using the stepper exposure used for a semiconductor aligner, combining the process of resist application, pattern exposure, and etching **, it is high and excels in mass-production nature, and a process tolerance is cheap and can fabricate the diffraction grating of a large area comparatively. Therefore, the implementability of a diffraction grating is very easy for the polarization separation element shown in (drawing 2), it is more excellent in mass-production nature, and can realize the cheap element of cost.

[0058] Hereafter, a drawing and a numerical example are given and the concrete operation form of the polarization separation element of this invention and projected type display is described.

[Example 1 of a polarization separation element] As the 1st example of a polarization separation element, what was

shown in (drawing 3) is stated more to a detail.

[0060] For example, a refractive index uses a diffraction grating 102 as the isotropic transparent body of 1.6. Moreover, the birefringence layer 103 makes an optical axis in agreement with the z-axis, carries out orientation of the material which has positive form birefringence, and sets the refractive index of z shaft orientations to the 1.6 [same] as the refractive index of a diffraction grating. Moreover, the refractive index of y shaft orientations which intersect perpendicularly with this is set to 1.45.

[0061] The above-mentioned composition is realizable by stiffening organic molecules generated appropriately, for example, such as a liquid crystal polymer and a liquid crystal monomer, where orientation is compulsorily carried out on a diffraction grating 101. There are adding the suitable magnetic field which performs rubbing processing after applying a polyimide film as an orientation means, for example, adding suitable electric field, etc.

[0062] For example, in order to make the separation angle theta of primary polarization 104A and secondary polarization 104B into 8 times, (1) formula is used and the pitch D of a diffraction grating 102 is set to 3.95 micrometers. However, 550nm with the highest visibility was chosen as criteria wavelength lambda.

[0063] In this case, although an angle of diffraction theta changes depending on wavelength, it is small the extent, and when using as a polarization separation element, especially a problem does not have it. for example, in the case of D= 3.95 micrometers, an angle of diffraction comes out about the light of blue with a wavelength of 490nm, and an angle of diffraction comes out 8.8 degrees about light with a wavelength of 610nm 7.1 degrees

[0064] Moreover, in order to make primary [+] diffraction efficiency into the maximum about secondary polarization 104B, it considers as H= 3.67 micrometers of maximum heights of a diffraction grating from (2) formulas. Thereby, about light with a criteria wavelength of 550nm, almost all the light of secondary polarization 104B is diffracted, and it dissociates in the direction of angle theta. Although diffraction efficiency will fall if wavelength differs, diffraction efficiency practically sufficient in a visible full wave length band can be obtained.

[0065] (Example 2 of a polarization separation element) As the 2nd example of a polarization separation element, what was shown in (drawing 4) is stated more to a detail. The composition and the numeric parameter which were applied for setting in the 1st example of the above (drawing 3) are mostly applicable to this appearance at (drawing 4). Thereby, polarization part elongation can constitute the polarization separation element which is 8 times like the 1st example of the above.

[0066] The number of level of a diffraction grating 112 can obtain diffraction efficiency practically sufficient because it will take at least four or more about for eight if it can do.

[0067] It is a book, although the above 1st and the 2nd example defined the birefringence layers 103 and 113 as a positive optically anisotropic body and the direction of orientation was limited to y shaft orientations in them. It may be a negative optically anisotropic body, and even if it makes the optical axis of a birefringence layer in agreement with y shaft orientations, it is not cared about. The directions where the polarization direction of the primary polarization which goes straight on, or secondary polarization (diffracted light) turns at a diffraction grating only differ, like ****, mutually, it can dissociate as a light which makes angle theta and advances, and outgoing radiation of primary polarization and the secondary polarization is carried out.

[0068] Moreover, the above-mentioned polarization separation element has the advantage which can control the separation angle of polarization easily. That is, lattice-pitch D of diffraction gratings 102 and 112 is changed, and the angle theta which the separated primary polarization and secondary polarization make can be set up arbitrarily. When the optical system after a polarization separation element is constituted, since the flexibility of this on a design increases, it is very desirable.

[0069] Furthermore, although the above-mentioned example described the case where incidence of the incident light was carried out from the substrate side of a diffraction grating, even if it carries out incidence from a birefringence layer side, the same operation and the same effect can be acquired.

[0070] (Example 1 of projected type display) The 1st example of the projected type display of this invention is hereafter described using (drawing 5).

[0071] the projected type display of this invention -- fundamental -- a lamp 121, a parabolic mirror 122, the polarization separation element 123, the 1st lens array 124, the 2nd lens array 125, the field lens 126, a liquid crystal panel 127, and the projection lens 128 -- shell composition is carried out. The phase contrast board 129 is partially stuck on one side of the 2nd lens array 125. In order to give explanation easy, the same rectangular coordinate system as (drawing 3) is introduced, and let the direction of an optical axis which met the symmetry axis of rotation inversion of a parabolic mirror 122 in the x axis, and the z-axis be the directions which intersect perpendicularly with space.

[0072] A liquid crystal panel 127 **** a twist nematic liquid crystal general to this use with the glass substrate which has pixel structure, and equips an incidence and outgoing radiation side with polarizing plates 127A and 127B. For convenience, let the transparency shaft (the oscillating direction of the electric field of the light made to penetrate) of incidence side polarizing plate 127A be z shaft orientations. A video signal is supplied to a liquid crystal panel 127 from the exterior, and an optical image is formed in it according to 2-dimensional-like pixel structure. The optical image concerned is projected on a screen with the projection lens 128, and makes a big screen image show.

[0073] The polarization separation element 123 is shown in the example 1 of the polarization separation element of this invention, and it comes to constitute it like (drawing 3). It comes appropriately to constitute serrate diffraction-grating 123A periodically constituted by y shaft orientations and positive optically uniaxial optically-anisotropic-body 123B by which orientation was carried out to z shaft orientations.

[0074] The 1st lens array 124 comes to arrange two or more 1st lenses 131 in the shape of-dimensional [2], and shows an example of the composition to (drawing 6). About the rectangular coordinate system introduced by (drawing 5), the

correspondence is shown in inside (drawing 6). This is made inscribed in the flux of light cross section of the right circle which carries out outgoing radiation from a parabolic mirror 122, and makes the 1st 18 lens 131 arrange. Each optical-axis center of the 1st lens 131 is 131A, and carries out eccentricity appropriately about all lenses.

[0075] The 2nd lens array 125 comes to arrange two or more 2nd lenses 135 in the shape of-dimensional [2], and shows an example of the composition to (drawing 6) and this appearance at (drawing 7). Each of the 2nd lens 135 makes the 1st lens 131 correspond, and comes to arrange the same number similarly. Each of the 2nd lens 135 cheats out of opening of the 1st corresponding lens 131, and the viewing area of a liquid crystal panel 127 as conjugate mutually, and draws on a panel the flux of light which passes each lens with a superposition gestalt.

[0076] every -- the 2nd lens 135 -- the phase contrast board 129 is about stuck on a half field appropriately alternatively The phase contrast boards 129 should just be $\lambda/2$ of phase contrast boards about the wavelength λ which uses in order to rotate the plane of polarization of the light which carries out incidence about 90 degrees, and represents the passing light. A suitable direction is chosen so that the optical axis may achieve the operation mentioned later. The direction 136 and the direction of an optical axis of the phase contrast board 129 around which it turned to z shaft orientations 45 degrees from y shaft orientations are made in agreement in this example.

[0077] By operation of the polarization separation element 123, only the predetermined angle theta shifts and advances to y shaft orientations to the primary polarization 141, and incidence of the secondary polarization 142 is carried out to the 1st lens array 124. About the 2nd one lens 135, the field without the phase contrast board 129 is an opening field for the primary polarization 141, and sets the center of gravity to 135A. The field with the phase contrast board 129 is an opening field for the secondary polarization 142, and sets the center of gravity to 125B.

[0078] It is good to define optical-axis center 131A of the 1st lens 131 so that converged primary polarization 141' may pass near [above-mentioned] the center-of-gravity 135A. Moreover, converged secondary polarization 142' passes through the position from which only predetermined distance shifted to y shaft orientations on opening of the 2nd lens 135. If the above-mentioned polarization part elongation theta is chosen appropriately, it can cheat out of the passage position of converged secondary polarization 142' near [above-mentioned] the center-of-gravity 135B.

[0079] It is separated into the primary polarization 141 whose oscillating directions of electric field are z shaft orientations, and the secondary polarization 142 which is y shaft orientations by the polarization separation element 123, and to y shaft orientations, mutually, the light of the natural polarization emitted from a lamp 121 turns into light which accomplishes ** theta and advances, and carries out incidence of these to the 1st lens array 124. The light converged by the 1st lens array 124 forms a dispersed lighting spot on opening of the 2nd lens array 125, and the phase contrast board 129 is alternatively inserted only in the passage field of secondary polarization, and it is in it, and a wave front rotates 90 degrees and serves as z shaft orientations from the above-mentioned composition. the primary polarization 141 which reaches incidence side polarizing plate 127A -- since each plane of polarization of "and secondary polarization 142" serves as z shaft orientations, these are effectively used as a light which passes a polarizing plate and illuminates a liquid crystal panel 127

[0080] According to the above-mentioned composition, conventionally, since the light of the secondary polarization which was absorbed with the incidence side polarizing plate and lost can be used effectively, high projected type display of efficiency for light utilization can be realized, and a bright projection picture can be offered.

[0081] The polarization separation element 123 used for the above-mentioned projected type display consists of a diffraction grating and the birefringence optical layer constituted appropriately, and since the thickness which needs a birefringence optical layer is very thin, it carries out orientation of the optically uniaxial optically anisotropic bodies, such as a liquid crystal polymer, to about several microns good, and it can constitute it.

[0082] Moreover, since the path of the above-mentioned lighting light is the optical path length almost equal about primary polarization and secondary polarization, incidence of the great portion of light condensed by the parabolic mirror 122 is carried out to the 1st lens array 124 and a liquid crystal panel 127 is reached through the 2nd lens array 125, primary polarization and secondary polarization can realize high efficiency for light utilization. Thereby, the high polarization conversion optical system of the effect which raises a luminosity is realizable.

[0083] (Example 3 of a polarization separation element) The 3rd example of a polarization separation element is described using (drawing 8). When it uses for projected type display as shown in (drawing 5), the polarization separation element 151 is constituted so that the exceptional effect described below may be demonstrated.

[0084] (Drawing 8) is the front view of the polarization separation element 151, and that of the composition of the direction of a cross section is the same as that of the 1st example of the polarization separation element of the above-mentioned this invention, or the 2nd example. However, two or more diffraction-grating 151A which constitutes a polarization separation element is arranged in the shape of-dimensional [2]. Moreover, the effective field of each diffraction-grating 151A is used as rectangle opening, and diffraction pitches are made to differ appropriately in each field. Sticking the positive optically-anisotropic-body layer by which orientation was carried out to 1 shaft orientations on the front face of these array-like diffraction gratings, primary polarization makes rectilinear propagation and secondary polarization diffract, and separates the light which carries out incidence. In order that wavy line hatching in rectangle opening may show typically signs that the periodic pitches of the diffraction grating of each rectangle opening field therefore differ in a place, in (drawing 8), it writes in addition.

[0085] The polarization separation element 151 can be embodied according to the following procedures. First, according to the kind of required polarization part elongation, the diffraction grating of a periodic pitch with which plurality differs is formed. concrete composition -- or (drawing 3) (drawing 4) it is the same as that of what was shown, and the matrix of the shape of a lattice type which should be embodied is fabricated according to mechanical precision processing, a FOTORISO process, etc.

Start these matrices in the rectangle opening configuration which was able to be given, plurality is made to arrange appropriately, it constructs, and a mold is constituted. If press forming of the transparent resin material etc. is carried out by making this into a matrix, the diffraction-grating substrate of the polarization separation element 151 will be obtained. What is necessary is to have by legal force, such as rubbing processing, and electric field or a magnetic field, to carry out compulsion orientation of the optically uniaxial optically anisotropic body, and just to hold the state by technique, such as ultraviolet-rays hardening, about the diffraction-grating side of this. It can embody easily with the gestalt which this arranged [gestalt] the same element as the 1st or 2nd example of the polarization separation element of the above-mentioned this invention in the shape of-dimensional [2], and made polarization part elongation differ suitably.

[0086] The above-mentioned composition is characterized by the separation angles of the light of the primary polarization which carries out outgoing radiation from the polarization separation element 151, and secondary polarization differing therefore more preferably in a place. Thus, in the projected type display constituted combining this, the constituted polarization separation element has the more high flexibility of a design, and has the advantage which can realize optical system with more high efficiency for light utilization.

[0087] (The 2nd example of projected type display) When it constitutes the same projected type display as (drawing 5) using the 3rd example of the polarization separation element of the shown this invention, an example of composition of that a bigger effect can be acquired is described (drawing 8).

[0088] (Drawing 9) is an example of the composition of the 1st lens array 161. 36 1st lens 161A which has rectangle opening is arranged in the shape of-dimensional [2]. Each opening of 1st lens 161A is the viewing area and similarity configuration of a liquid crystal panel to illuminate. Eccentricity of the optical axis of 1st lens 161A is suitably carried out about each. If it carries out like this, arrangement of the lighting spot which each 1st lens forms on the 2nd lens array can be adjusted comparatively freely. (Drawing 9) has the advantage whose homogeneity of the luminosity of the light which illuminates a liquid crystal panel improves that efficiency for light utilization is made highly, when the number of a lens is made [many] as compared with the composition shown in (drawing 6).

[0089] An example of the composition of the 2nd lens array 162 which is used as reference combining the 1st lens array of the array and opening configuration which were shown in (drawing 9) in the conventional composition which does not use a polarization separation element is shown in (drawing 10). On opening of the 2nd lens array 162, two or more lighting spots converged by the 1st lens array are formed. This is equivalent to the real image 163 of the emitter in a lamp, and appends an example of the size and a distribution to inside (drawing 10) typically.

[0090] Since it states below, openings of the 2nd lens 164 which constitutes the 2nd lens array 162 are made to differ appropriately according to the size of the real image 163 formed on the opening concerned, condense and arrange these, and make the breadth of effective opening of the whole 2nd lens array as small as possible. Therefore, according to the opening position of the 2nd corresponding lens 164, the eccentric direction and eccentricity of the 1st corresponding lens are decided.

[0091] The illuminating angle to the liquid crystal panel 127 of the light which carried out outgoing radiation from the 2nd lens array 125 with reference to (drawing 5) is equal to the converging angle of the projection lens 128, or if it is not less than [it], the light which cannot pass a projection lens effectively will occur and it will produce optical loss. Therefore, the breadth of effective opening of the 2nd lens array seen from the liquid crystal panel has a desirable thing small as much as possible. This is making as small as possible the illuminating angle of the lighting light which passes a liquid crystal panel.

[0092] Arrangement of the opening configuration of the 2nd lens array 162 shown in (drawing 10) from this reason and two or more real images 163 is convenient. The right circle 165 shown with the wavy line writes a more desirable example of the condensing range of a projection lens on the 2nd lens array, and shows it. It can consider that this right circle 165 is the entrance pupil of a projection lens, and can treat as the size of the real image of two or more emitters and distribution which can set a real image 163 on the entrance pupil concerned. Here, the higher optical system of a pupil utilization factor, then a pupil utilization factor can say the rate for which total of the flare (area) of two or more real images 163 accounts to the flare (area) of an entrance pupil as optical system brighter and desirable for projected type display.

[0093] In the projected type display shown in (drawing 5), using the polarization separation element 151 shown in (drawing 8) acquires a very high effect, when realizing high optical system of a pupil utilization factor. An example of the composition of the 2nd lens array 171 used combining the 1st lens array 161 concretely shown in the polarization separation element 151 shown in (drawing 8) and (drawing 9) is shown in (drawing 11), and this reason is explained.

[0094] The 2nd lens array 171 makes the 2nd lens 172 with which the size of opening differs from a configuration condense in the effective field of the right circle 173, and it comes to arrange it. The phase contrast board which was divided with the wavy line of each 2nd lens 172 and which makes a half field (it illustrates by hatching for convenience) rotate the plane of polarization of secondary polarization which passes through the field concerned 90 degrees is stuck about. In order to clarify the correspondence relation of each lens, the number of (1) - (36) is appended to the 1st lens array 161 of (drawing 9), and the 2nd lens array 171 of (drawing 11).

[0095] The size of the real image by which the composition of the 2nd lens array 171 is formed on each 2nd lens 172 is as large as [near the optical axis], the real image which the 1st lens array forms is arranged, and the opening configuration and array of a lens corresponding to it are constituted so that it may use positively that it is so small that it separates from an optical axis and a pupil utilization factor may become larger. In this case, the size of the real image constituted on the 2nd lens array 171 and an example of a distribution are typically appended to inside (drawing 12) like (drawing 10).

[0096] 36 real images 175 shown as the solid line are the lighting spots about primary polarization components which pass the 1st lens array. Each real image 175 carries out eccentricity of the 1st lens 161A suitably so that it may be arranged in the position

where opening of the 2nd corresponding lens corresponds.

[0097] Similarly the real image 176 shown with the dashed line is a lighting spot about secondary polarization components. Of an operation of the polarization separation element 151, to the real image 175 about primary polarization, only predetermined distance shifts in the predetermined direction and these real images 176 are formed in it. However, if the opening configuration and array of the 2nd lens 172 are changed in order to raise a pupil utilization factor, it is necessary to make the polarization part elongation of the primary polarization which passes the 1st lens concerned, and secondary polarization differ suitably for every pair of each 1st lens and the 2nd lens. According to the distance of the real image 175 which should be shifted on the 2nd lens array 171, and a real image 176, it is necessary to define the polarization part elongation concerned suitably.

[0098] The polarization separation element 151 shown in (drawing 8) consisted of reasons for the above, and can make the polarization part elongation of two polarization light which is in the near at every [to which it corresponds on the 1st lens array 161] 1st lens 161A, and passes the lens concerned differ easily suitably. Since the polarization separation element 151 comes to combine a diffraction grating, it makes the diffraction pitches in the inside of each rectangle field only differ suitably, and has the advantage which can control polarization part elongation easily.

[0099] Concretely, it is a book. In the 2nd example of the projected type display of the above-mentioned this invention, the optical path length from the 2nd lens array to a liquid crystal panel is fixed, and the size and pupil use efficiency of effective opening of the 2nd lens array are described.

[0100] In order to use without loss of the light which is emitted from the spreading real image 163 in the conventional composition which does not use the polarization separation element shown in (drawing 10), under [the size of a dashed line 165 is required for the entrance pupil of a projection lens, it converts this into the f number and it is equivalent to $F/2.5$]. In this case, the pupil utilization factor was about 33% as a rate for which it accounts in the area of an entrance pupil (right circle of a radius 165) of total of the flare (area) of a real image 163.

[0101] In order to use without loss of the light which is emitted from the spreading real images 175 and 176 in the composition using the polarization separation element of this invention shown in (drawing 12), under [the size of the right circle 177 is required for the entrance pupil of a projection lens, it converts this into the f number and it is equivalent to $F/2.3$]. In this case, the pupil utilization factor was about 57%.

[0102] If both are compared, by this invention, without enlarging the converging angle of a projection lens not much, a pupil utilization factor is raised twice [about] and efficiency for light utilization high enough can be realized about the component of both primary polarization and secondary polarization. Since this may not enlarge aperture of a projection lens, it can realize optical system with more cheap cost. Or since the lamp of a smaller emitter may not be used, brighter projected type display is realizable using a brighter reliable lamp.

[0103] Thereby, the polarization separation element of the invention in this application and the projected type display using this have high efficiency for light utilization, and since they offer a bright projection picture, they acquire a very big effect.

[0104]

[Effect of the Invention] Since the polarization separation element of this invention comes to combine a diffraction grating and an optically uniaxial optically anisotropic body, it has the advantage of composition being simple, and polarization separation efficiency being high, and being easy to control polarization part elongation. moreover, easy in optically uniaxial different ****, such as a liquid crystal polymer, since the thickness to which orientation of the optically anisotropic body is carried out is as thin as about several microns -- and -- good -- orientation -- it is filled up and a desired element can be easily realized by high mass-production nature

[0105] Furthermore, the projected type display of this invention can offer the bright few projection picture of display unevenness using the polarization separation element of the above-mentioned this invention.

[Translation done.]

*** NOTICES ***

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

- [Drawing 1] The abbreviation diagram for explaining a general operation of a diffraction grating
[Drawing 2] The abbreviation diagram for explaining a general operation of other diffraction gratings
[Drawing 3] The abbreviation block diagram showing one example of the polarization separation element of this invention
[Drawing 4] The abbreviation block diagram showing one example of other polarization separation elements of this invention
[Drawing 5] The abbreviation block diagram showing one example of the projected type display of this invention
[Drawing 6] The abbreviation block diagram showing an example of the composition of the 1st lens array
[Drawing 7] The abbreviation block diagram showing an example of the composition of the 2nd lens array
[Drawing 8] The abbreviation block diagram showing one example of the polarization separation element of further others of this invention
[Drawing 9] The abbreviation block diagram showing other examples of the composition of the 1st lens array
[Drawing 10] The abbreviation block diagram showing an example of the conventional composition of the 2nd lens array
[Drawing 11] The abbreviation block diagram showing other examples of the composition of the 2nd lens array
[Drawing 12] The ** type view showing an example of the real image of the emitter formed on the 2nd lens array
[Drawing 13] The abbreviation block diagram showing an example of the conventional projected type display
[Drawing 14] The abbreviation block diagram showing an example of the conventional polarization separation element

[Description of Notations]

- 101,111,123,151 Polarization separation element
102,112 Diffraction grating
103,113 Optically uniaxial optically anisotropic body
121 Lamp
122 Parabolic Mirror
124,161 The 1st lens array
125,171 The 2nd lens array
126 Field Lens
127 Liquid Crystal Panel
128 Projection Lens
129 Phase Contrast Board

[Translation done.]